Honors Seminar 256 — cheat sheet for 10/6/2011 — Andrew Baker

Koch et al. (2010)

You should read the abstract and Sections 1–3. Key questions:

1. What are the four "requirements" that the authors identify as defining the parameters of the *Kepler* mission, and what are the reasons for those requirements?

2. What would be the advantages of extending the *Kepler* mission beyond three years?

3. Is there any aspect of the *Kepler* mission that might have been different if it had been an Australian rather than an American project?

Key terms:

- **asteroseismology** = study of stars' oscillations as a means of understanding their structures

- **astrometry** = area of astronomical research focused on very precise measurements of the positions of stars and other sources in the sky

- **cadence** = frequency of observation, in the sense of daily, weekly, etc.

- **centroid** = estimate of the central position of a star or other object, which can be determined even if the image of the star/object is very distorted

- **commissioning** = process of bringing a complicated piece of equipment on line and verifying that it works as expected

- **dwarf** = a star whose "dwarf" mass puts it on the main sequence in the HR diagram

- **earthshine** = sunlight reflected off the Earth

- **ecliptic** = plane in which Earth and the other planets orbit the Sun

- **field-flattening lens** = type of lens that can be inserted into a telescope's optical path in order to give it a large field of view

- **full well** = term characterizing how much charge an individual pixel in a digital camera can accumulate in the course of taking a picture

- **ghosting** = appearance of fake images that don't correspond to real astronomical objects

- **gyrochronology** = method of determining a star's age based in part on how fast it is spinning

- **integration time** = how long a camera keeps the shutter open while taking a picture

- **megapixel** = one million pixels

- **Mg** b line = a particular absorption line that is seen in the spectra of the Sun and other stars

- **parsec** = pc = unit of distance corresponding to about 3.3 light-years; a kiloparsec is 1000 parsecs (the distance from the Sun to the center of the Milky Way is about 8 kiloparsecs)

- **pointing jitter** = tendency of any telescope not to stay perfectly aligned with whatever it is nominally pointed at, but instead to jump around a bit

- $R_\oplus$ = radius of the Earth

- $R_\odot$ = radius of the Sun

- **saturated pixel** = pixel in a digital camera whose well is nearly full (see "full well" above)

- **Schmidt telescope** = an optical telescope design that is optimized for observations of wide areas on the sky

- σ = symbol used to represent the noise or uncertainty of a measurement; a 5σ detection is more credible than a 3σ detection because it stands out higher above the noise

- **semimajor axis** = half of the (larger) diameter of an ellipse; for a planet, this can be considered the radius of its orbit as long as the eccentricity is not too high

- **shot noise** = uncertainty in an astronomical measurement that is due to the facts that you're only measuring a small number of photons, and that small numbers can suffer from (relatively) large fluctuations

- **Sloan Survey** = a major digital sky survey providing imaging and spectroscopy over a very large northern/equatorial region of the sky, executed by a consortium of universities led by Princeton

- **solar avoidance angle** = minimum angle by which a space telescope *must* point in a different direction from the Sun, in order to avoid damaging itself

- **South Atlantic Anomaly** = region where the Earth's magnetic field is weakest, and therefore radiation in the Van Allen belt is strongest, risking damage to spacecraft that pass through it

- **Spitzer** = *Spitzer Space Telescope*, a NASA mission that is the infrared analog of the *Hubble Space Telescope*, now only partly working due to the exhaustion of its cryogens

- **stray light** = light that gets to a digital camera in spite of having originated from somewhere the telescope *isn't* pointing, as a result of various unanticipated reflections

- **velocity aberration** = change in the apparent position of an object due to the observer's motion relative to it

Borucki et al. (2011)

You should read the abstract and Sections 1–3, *except* for §2.2.1, 2.2.2, and 2.2.3, which you may skip. Key questions:

1. Radial velocity searches for exoplanets are best at finding large (massive) planets that are close to their stars. How do the initial *Kepler* results in this paper compare to the expectations we might have had based on radial velocity searches only?

2. Why does *Kepler* take some of its data every 58.85 seconds even though most of its data are taken every 29.4244 minutes?

3. How do the authors distinguish between "confirming" and "validating" the detection of a particular exoplanet? What happens to the name of a particular exoplanet when it is "confirmed"?

4. Why isn't *Kepler* good at finding planets that orbit around very large stars?

5. In Figure 4, which of the asterisks correspond to planets you might be reasonably comfortable living on? (Hint: don't forget the "greenhouse effect," which we'll talk about in more detail next week.)

6. At what orbital radius ("semimajor axis") do most of the detected exoplanets revolve around their stars? Is this the typical radius at which *all* exoplanets revolve around their stars, or does *Kepler* have a somewhat biased view?

7. Figure 9 is said to show that "small candidates are more numerous than large ones for longer orbital periods." How does the figure show this, and what do the authors speculate might be the reason?

Key terms:

- **AO** = adaptive optics = a technique in which a thin piece of glass in a telescope is very rapidly deformed so as to cancel out the effects of atmospheric turbulence and yield a nice, sharp image of a star

- **bar** = unit of pressure, with 1 bar corresponding to the pressure of the Earth's atmosphere

- **BGEB** = background eclipsing binary

- **Bond albedo** = fraction of *all* electromagnetic radiation that is reflected by a planet or other astronomical body

- **double-lined binary** = a binary star in which both stars show spectral line features that allow their radial velocities to be measured (for a single-lined binary, this is only the case for one of the two stars)

- **eclipsing binary** = a binary star in which the two stars pass in front of each other from the perspective of the Earth

- **gray-body** = adjective describing an object that radiates with constant emissivity over all wavelengths

- **insolation** = input of energy from a star

- **JD** = Julian Date, an astronomical calendar that uniquely identifies each day in history

- **log-log space** = format of a plot in which the logarithm of one quantity is plotted vs. the logarithm of another quantity

- **metallicity** = a measure of the fraction of material in a star, gas cloud, etc. that is comprised of elements heavier than helium (this is typically expressed in terms of the relative abundance of oxygen)

- **passband** = range in wavelength of light that an instrument can detect

- **pipeline** = complex software package capable of automatically analyzing the data from some instrument

- **proprietary user** = someone who has exclusive access to a particular dataset

- **radiative equilibrium temperature** = temperature of a planet at which the rate of heating by the star it orbits balances out the rate at which it *loses* heat

- **random noise** = noise that gets lower as one adds more data

- **RV** = radial velocity

- **selection effect** = a pattern seen in an observational dataset that is a result *not* of the general properties of the type of source being studied, but of the way by which your particular sample of that source was selected

- **speckle** = a technique in which very short images are taken and then combined in such a way as to cancel out the effects of atmospheric turbulence and yield a nice, sharp image of a star

- **synchronism** = situation in which the rotation period of a star is identical to the orbital period of a planet that revolves around it

- **systematic noise** = noise that does not get lower as one adds more data

Latham et al. (2011)

You should read the entire article. Key questions:

1. A major conclusion of this paper is that "systems with multiple transiting planets are less likely to include a transiting giant planet" than systems with only a single planet. How do *Kepler* data support this conclusion, and how do the authors explain it?

2. Does *all* systems with multiple transiting planets contain *no* transiting giant planets? What are the implications of the answer to this question?

3. Is there a difference in the properties of the stars that have single vs. multiple planets?

4. If *Kepler*'s mission is extended, do you think it would it make more sense to observe a different part of the sky or to continue to observe the part of the sky it is currently observing?

Key terms:

- **artifact** = feature in a set of data that is due to instrumental problems (and doesn't correspond to the reality of what is being studied)

- **CoRoT** = "COnvection ROtation et Transit planetaires = French space telescope whose mission includes hunting for exoplanet transits

- **detrend** = process by which a long, slow drift in a dataset is corrected for and removed

- **hierarchical triple** = system containing three bodies in which two bodies are in a very small-separation orbit while the third is in a large-separation orbit around the first two

- **Kolmogorov-Smirnov** = statistical test used to determine whether two samples might (or might not) be drawn from the same parent population

- **light curve** = visual representation of how a star's apparent brightness varies with time

- **mean motion resonance** = pattern in which one planet has an orbital period that is an integer multiple of a sister planet's orbital period

- **parent population** = the true, larger number of objects in a particular category from which one's particular sample is assumed to be drawn

- **point spread function** = particular two-dimensional pattern produced when a particular instrument takes an image of a star

- **Poisson noise** = uncertainty in an estimate that is based on counting something

- **Rossiter-McLaughlin effect** = apparent redshift or blueshift of a star's spectrum due to a transiting planet that temporarily covers up its approaching or receding side

- **safe mode** = a spacecraft's self-protective state, to which it retreats if something bad happens

- **spin/orbit alignment** = process by which the axis on which a planet spins becomes parallel to the axis about which it revolves around its star

- **transit time variation** = effect of one or more *additional* planets in an exoplanetary system on the timing of a given expolanet's transits, due to the gravitational tugs of the former on the latter